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# European air quality with the online multiscale MONARCH v2.0 Model

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Atmospheric Composition Group

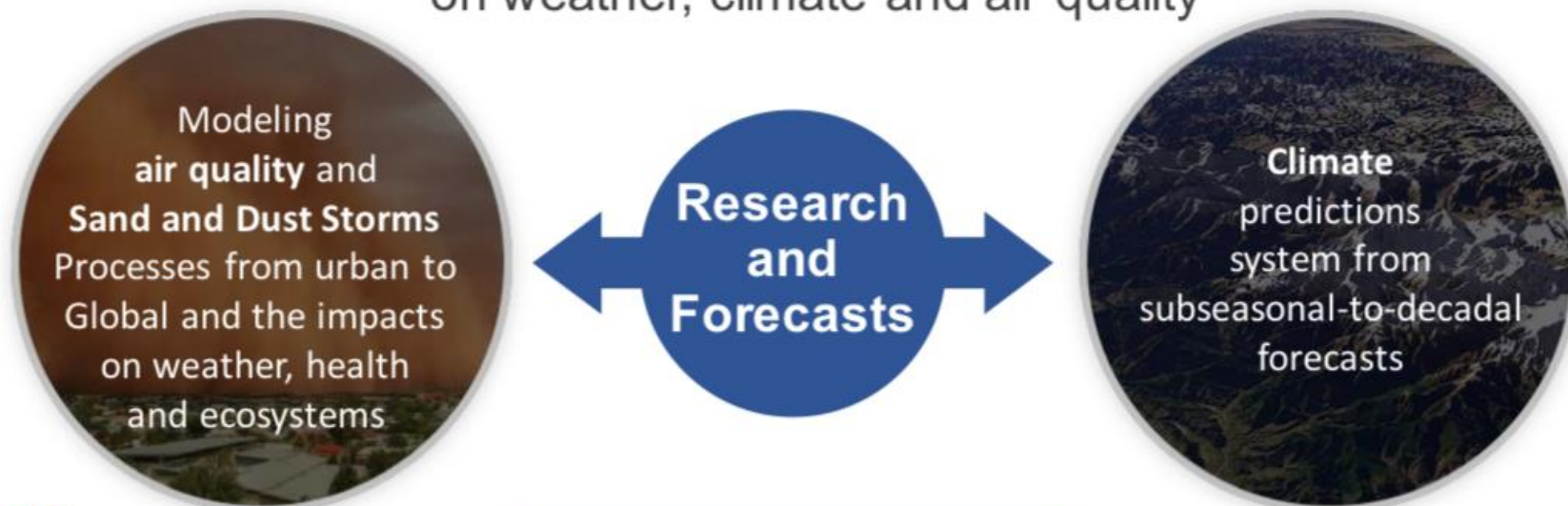
Earth Sciences Department of BSC

3/4/2019

27th GLOREAM Workshop, 1-3 April 2019,  
Norrköping, Sweden

# Earth Sciences Department

Environmental modelling and forecasting, with a particular focus on weather, climate and air quality



## Service Users Sectors



Infrastructures



Solar Energy



Urban development



Transport



Wind Energy



Agriculture



Insurance

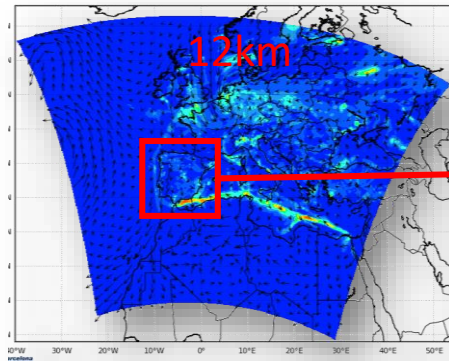


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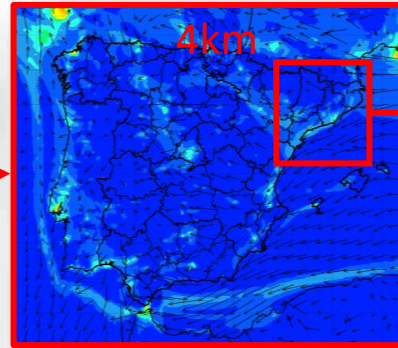
[www.bsc.es/ess/](http://www.bsc.es/ess/)



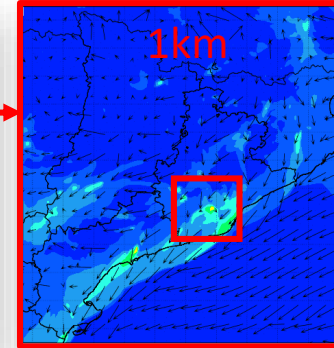
# CALIdad del aire Operacional Para España (CALIOPE)



Pay et al. (2011; 2012 AE)



Baldasano et al. (2012 AE)



Pay et al. (2014 GMD)

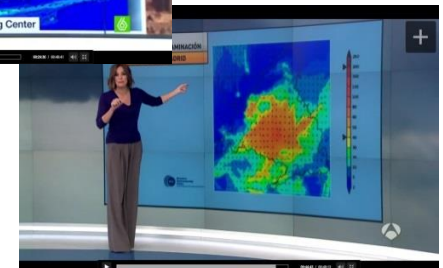
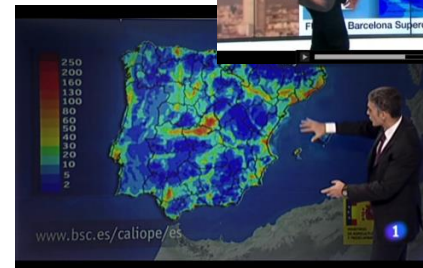
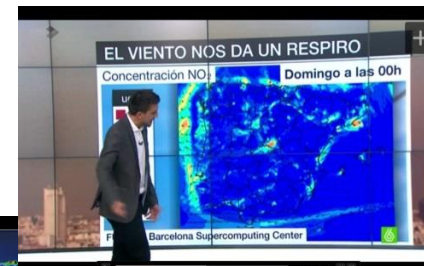
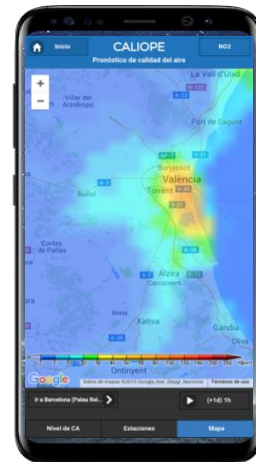
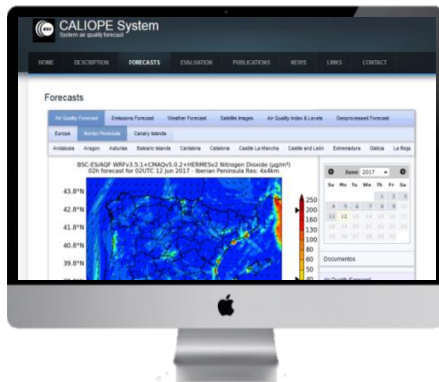


Benavides et al. (2019 GMDD)

Multiscale models from regional to local scales

Web / App

In the media



# Mineral dust services

## WMO Dust Centers

**Barcelona Dust Forecast Center.**  
Unique specialized WMO Center for  
mineral dust prediction in Europe

<http://dust.aemet.es>

started in 2014 - **Operations**

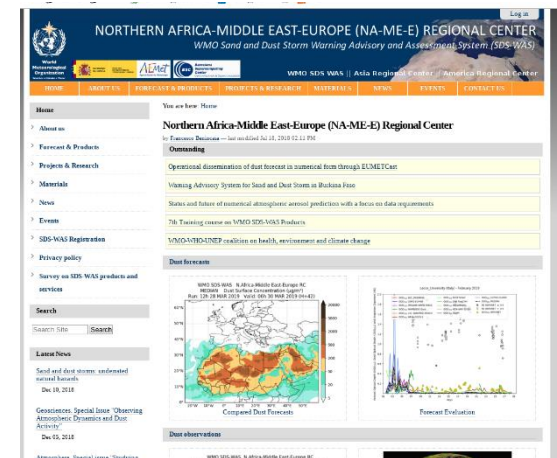
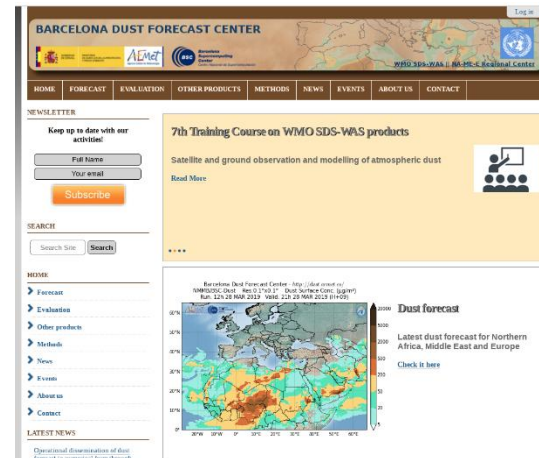
**MONARCH is the reference model**

**SDS-WAS. North Africa, Middle East and Europe  
Regional Center.**

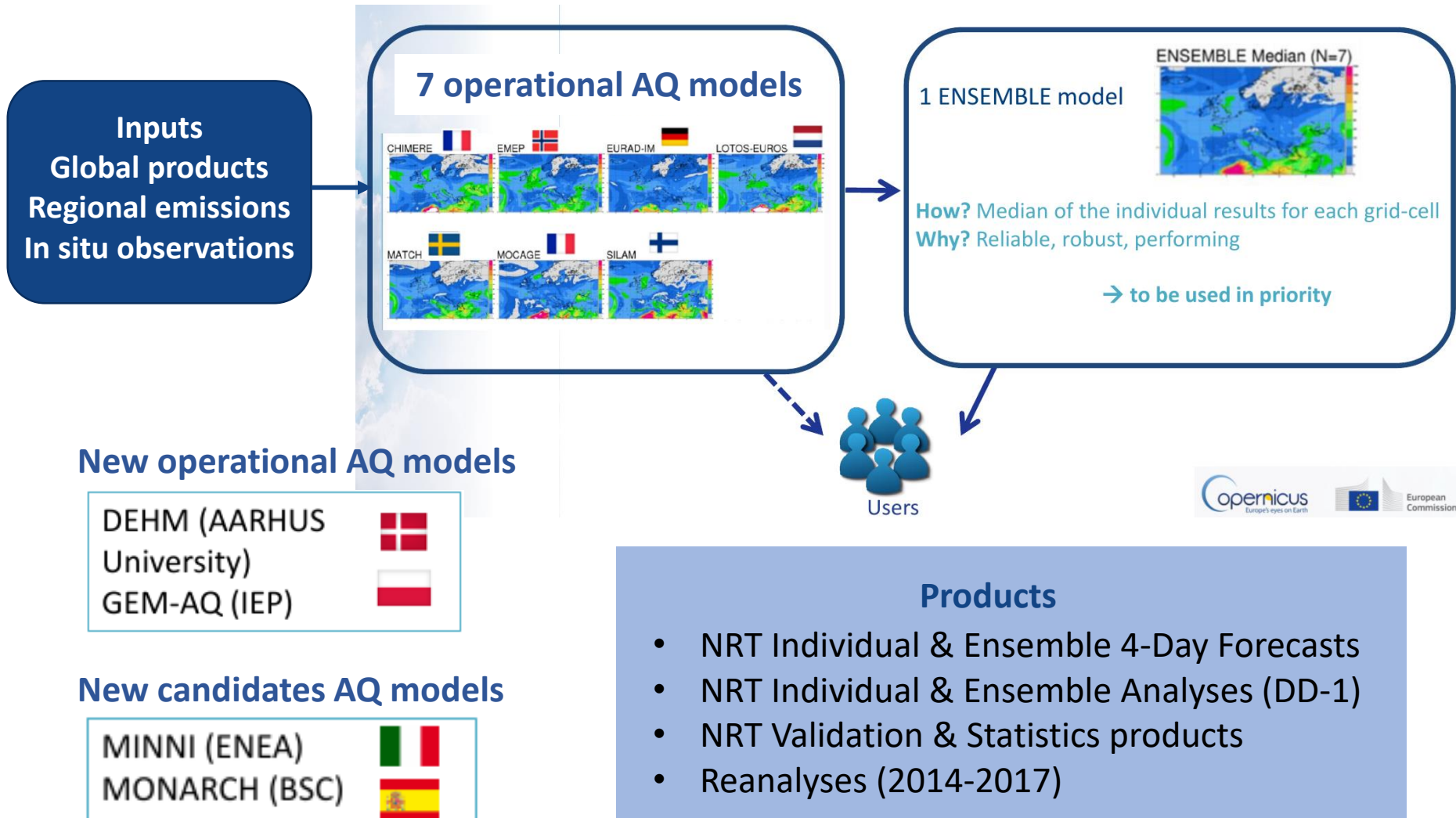
<http://sds-was.aemet.es>

started in 2010 – **Research**

**MONARCH is contributing to the model ensemble**



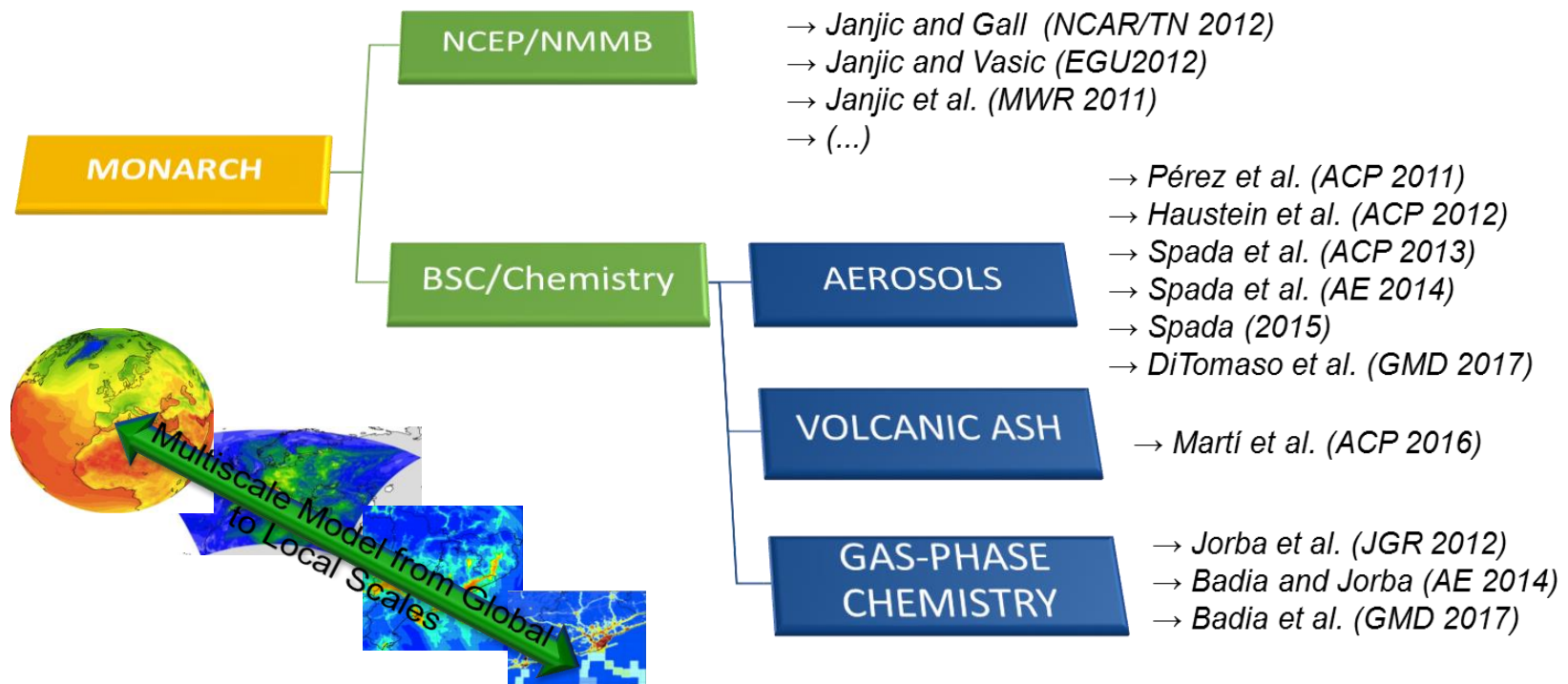
# CAMS\_50.II: Regional production\*



\*CAMS\_50.II: Augustin Colette's presentation yesterday

# MONARCH: online weather-chemistry model

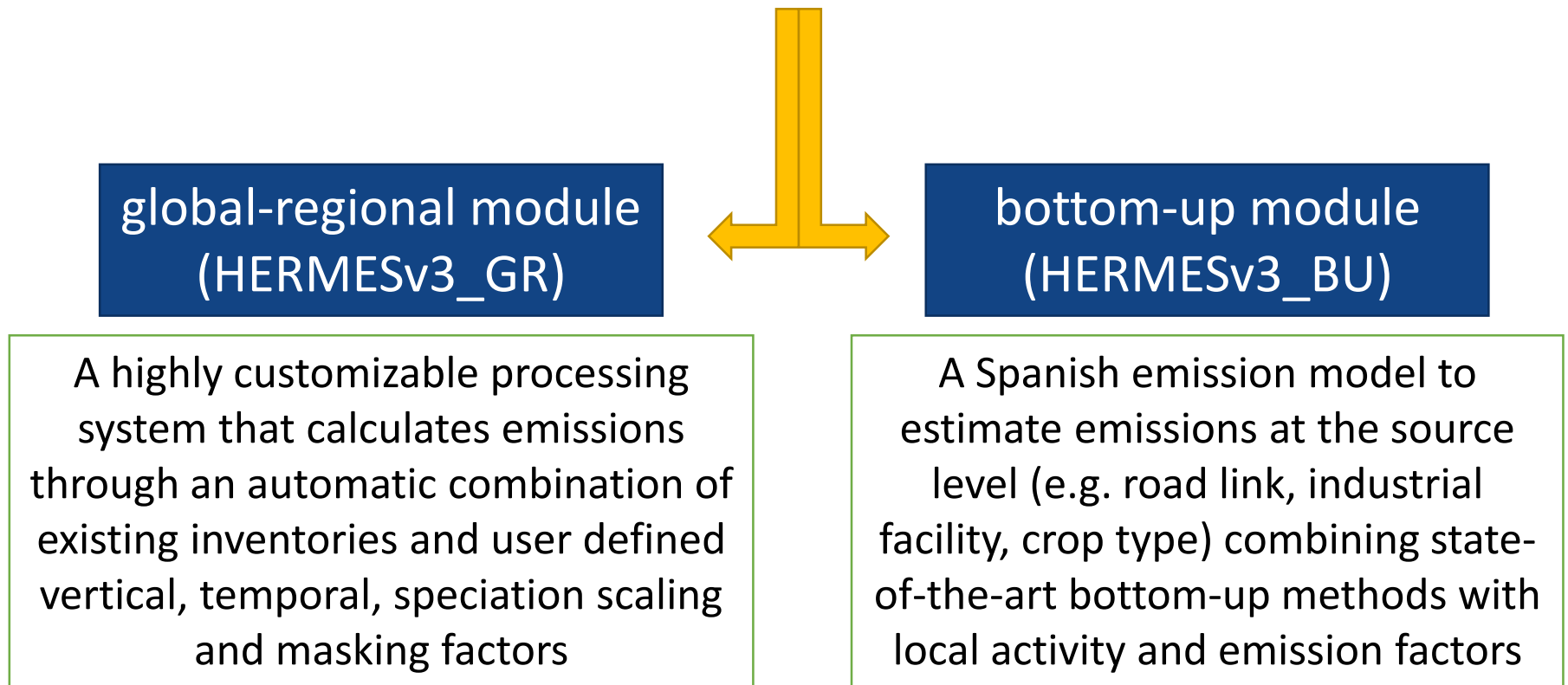
- Fully **on-line** coupling: weather-chemistry feedback processes
- In-house developed.
- **Multiscale**: global to regional (up to 1km) scales (nesting capabilities)
- Enhancement with a **data assimilation** system





# \*HERMESv3: emission model

An **open source, parallel and stand-alone multiscale** atmospheric emission model that **processes and estimates gas and aerosol emissions** for use in chemistry transport models

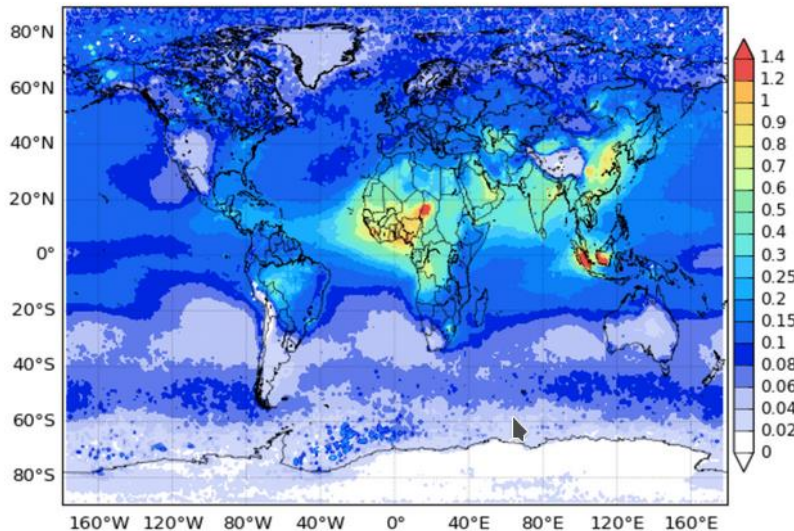


*\*HERMESv3: Marc Guevara's presentation yesterday*

# MONARCH forecasts

## Global

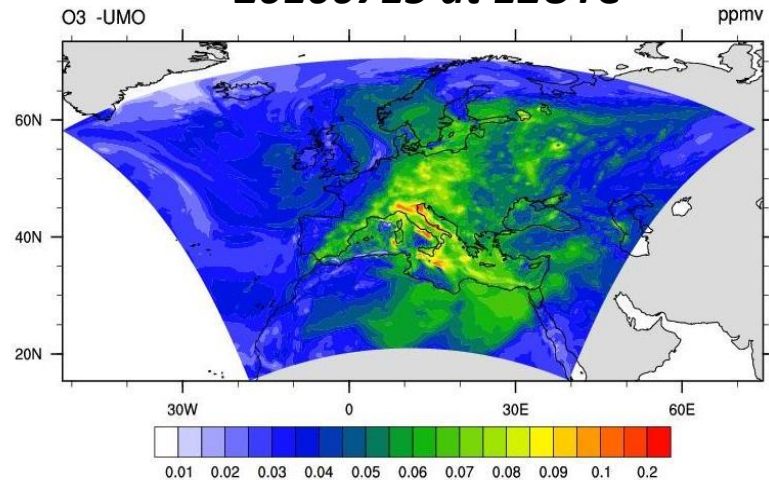
NMMB-MONARCH-b015 AOD550  
2015



- ✓ MONARCH contributes to the **ICAP global forecast aerosol** multi-model ensemble  
<http://icap.atmos.und.edu>

## Regional

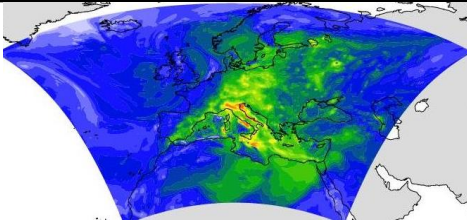
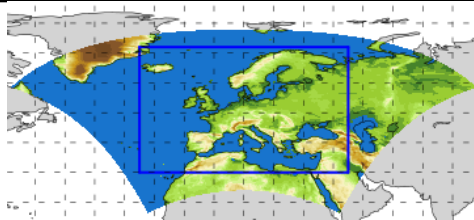
20100715 at 12UTC



- ✓ **BDFC** and **SDS-WAS** dust forecast
- ✓ Candidate model **CAMS\_50.11**
- ✓ It will be implemented in **CALIOPE** ([www.bsc.es/caliope](http://www.bsc.es/caliope))  
AQ Forecast System for **EU** and **Spain**



# MONARCH Experiment Configurations

	New model <b>CALIOPE (European domain)</b>	New candidate model <b>CAMS_50.II (Europe)</b>
<b>Year</b>	2015	2016
<b>Domain</b>	0.1° x 0.1° 48 layers (50hPa) 	0.2° x 0.2° 48 layers (50hPa) 
<b>Gas chemistry</b>	CB05 (extended with TU and CL chemistry)	
<b>Aerosols</b>	Primary (dust, sea salt, BC, POM, PSO4, PNO3, PNH4), SIA (EQSAM), SOA (2-product scheme)	
<b>Emissions</b>	<ul style="list-style-type: none"> <li>• HERMESv2: <b>EMEP2014</b></li> <li>• <b>GFASv1.2</b></li> <li>• MEGANv2.04</li> </ul>	<ul style="list-style-type: none"> <li>• <sup>1</sup><b>HERMESv3 (gr): CAMS-REG-AP_v2.1.1-2015 + CAMS-GLOB-2015</b> (ANTv2.1, SHIPv1.1, OCENv1.1, SOILv1.1) + <b>GFASv1.2</b></li> <li>• MEGANv2.04</li> </ul>
<b>IC-BC</b>	GFS/NCEP (met) - C-IFS (gas)	GFS/NCEP (met) - C-IFS (gas+aero)
<b>Evaluation method</b>	<ul style="list-style-type: none"> <li>• EIONET validated</li> </ul>	<ul style="list-style-type: none"> <li>• EBAS with <b>quality control flags</b><sup>2</sup></li> <li>• CAMS ens. + individ. models<sup>3</sup>.</li> </ul>

<sup>1</sup>HERMESv3: Marc Guevara's presentation yesterday

<sup>2</sup>Quality control flags: Dene Bowdalo's presentation

<sup>3</sup>CAMS\_50.I

# MONARCH vs CALIOPE

Period: full year 2015



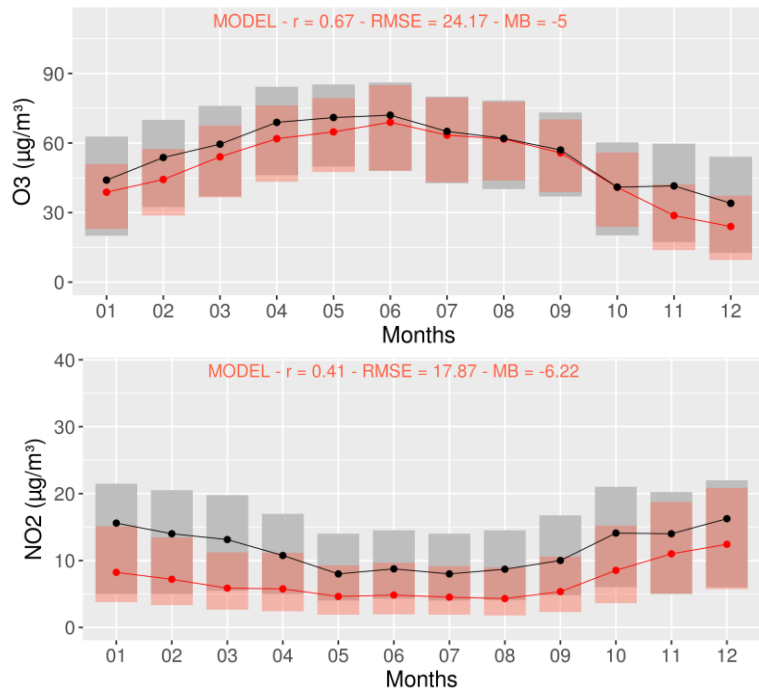
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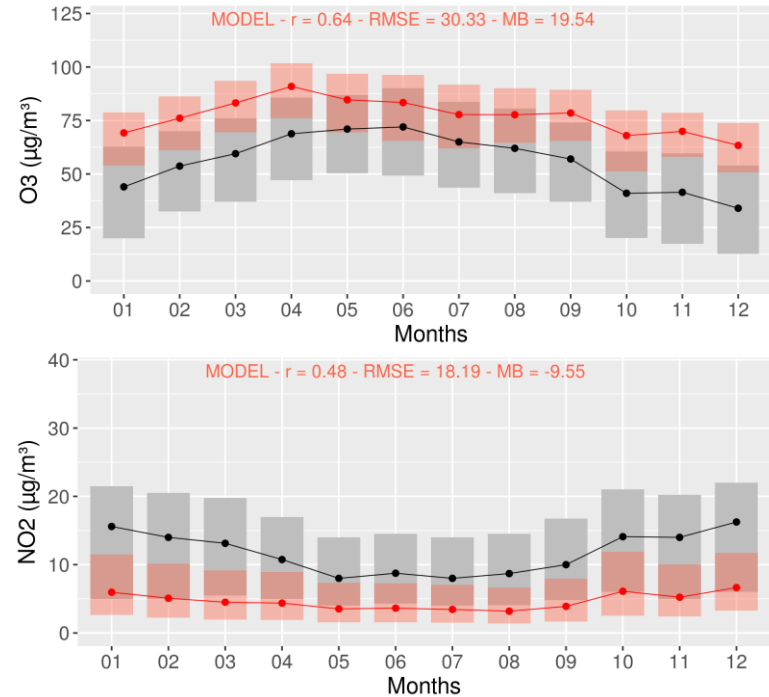
# MONARCH vs CALIOPE: annual cycle

Period: full year 2015

## MONARCH



## CALIOPE (WRF-CMAQ)



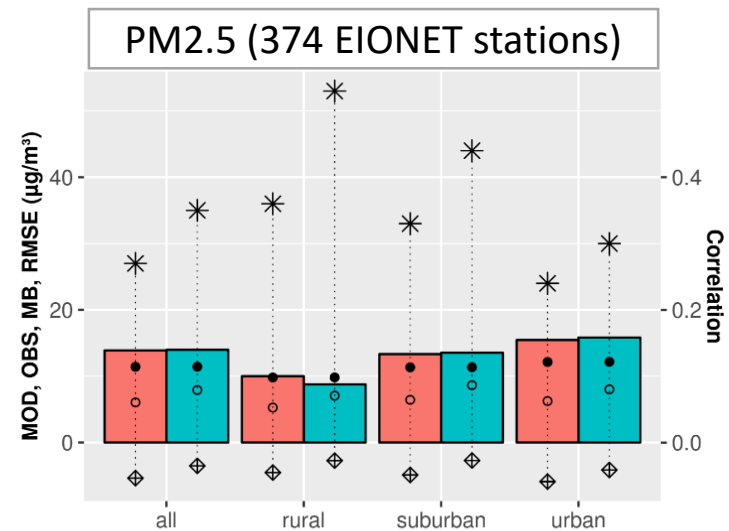
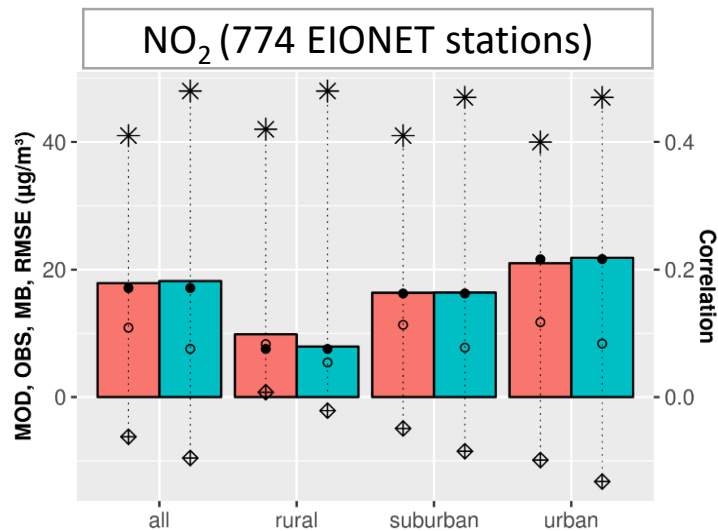
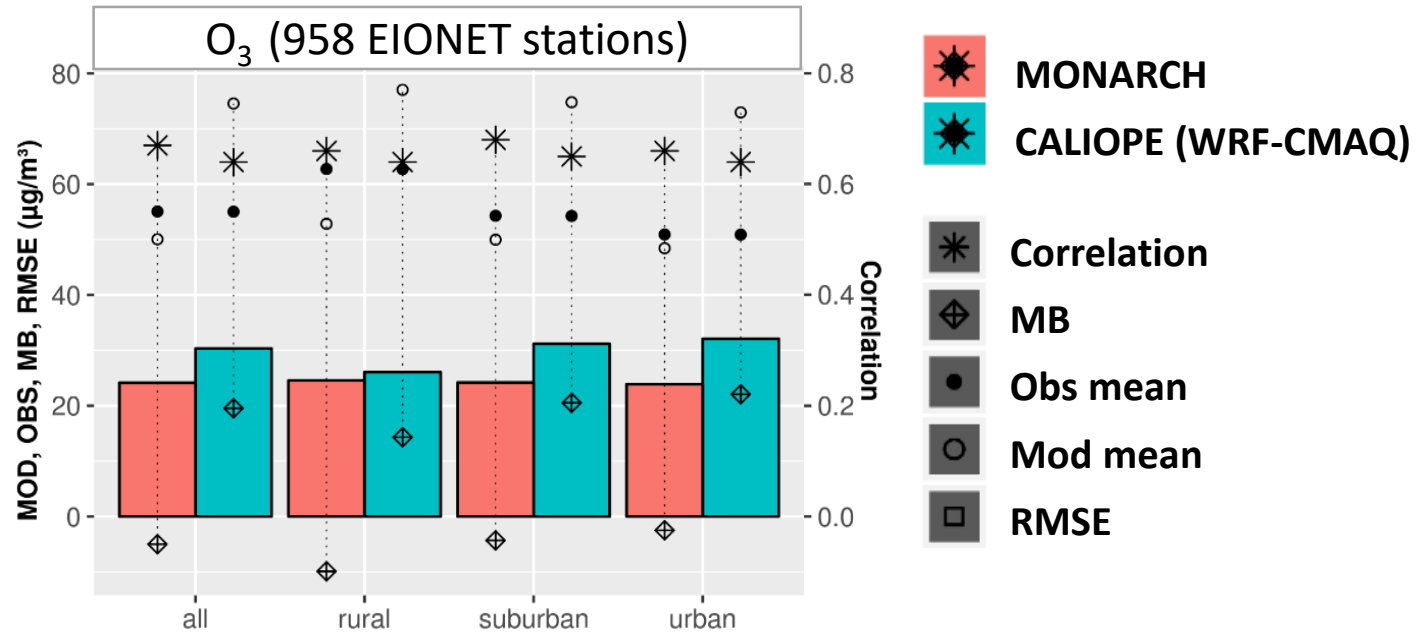
EIONET 2015 validated (rural, suburban, urban)

- 958 stations (O<sub>3</sub>)
- 774 stations (NO<sub>2</sub>)



# MONARCH vs CALIOPE: station category

Period: full year 2015



# **MONARCH vs CAMS\_50**

**Period: July-August 2016**



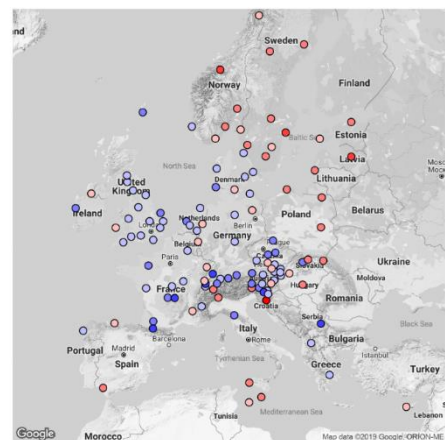
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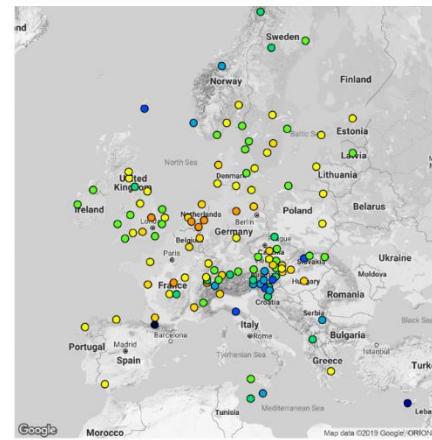
# MONARCH vs CAMS: O<sub>3</sub>

Period: 20160801-20160901

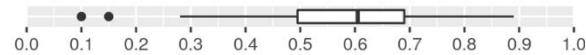
## MONARCH (113 EBAS stations)



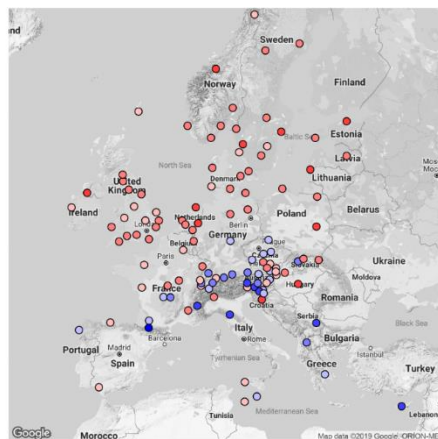
### MB (ppb)



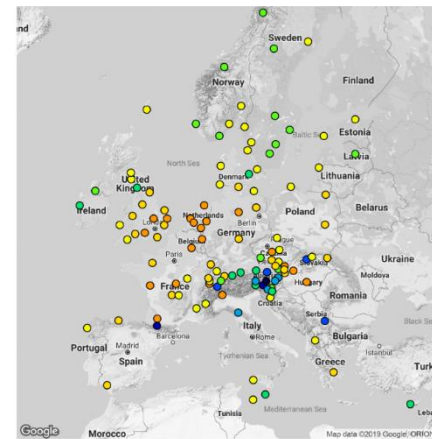
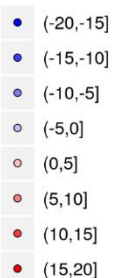
### PCC



## CAMS\_ENS (113 EBAS stations)



### MB (ppb)



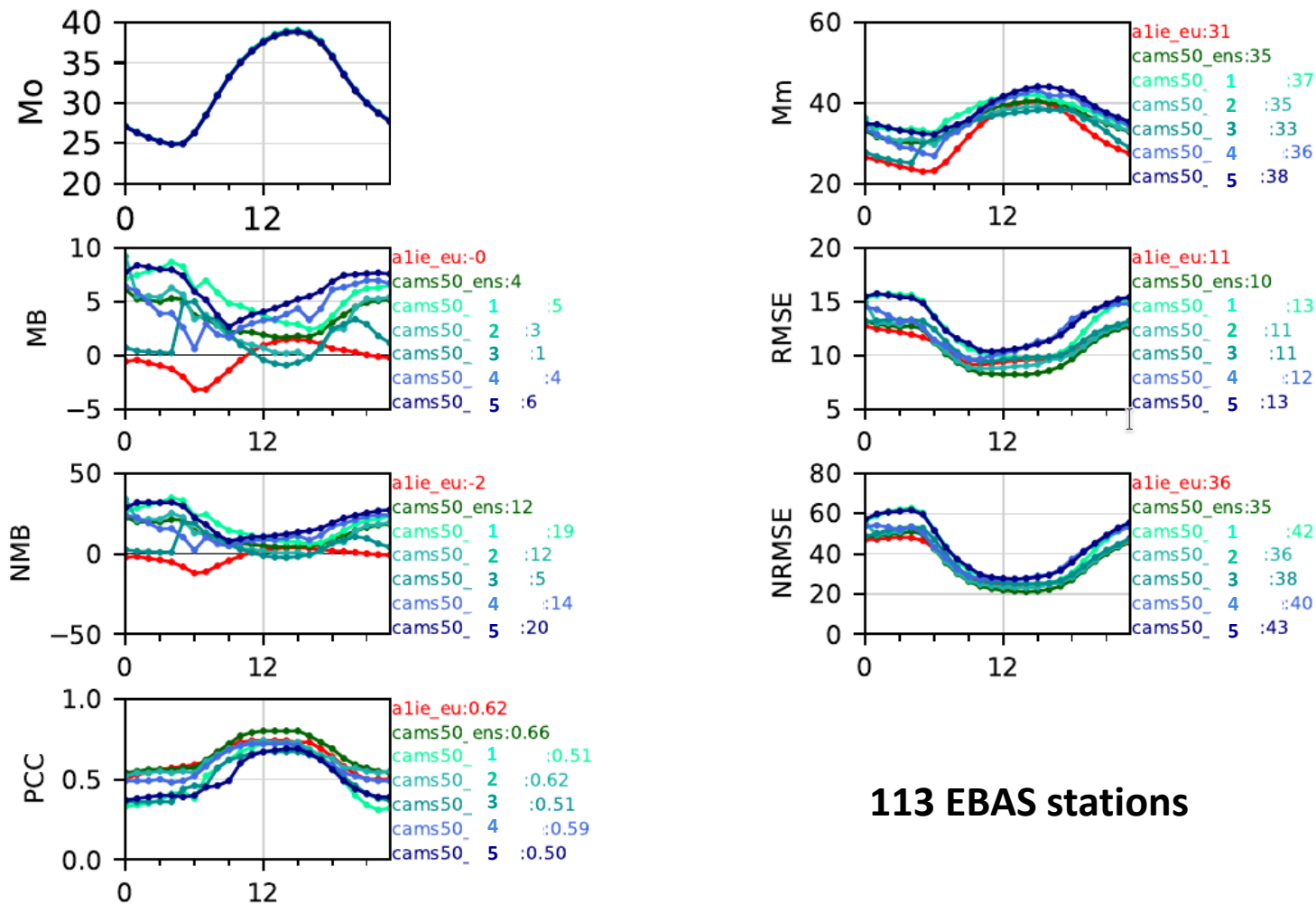
### PCC





# MONARCH vs CAMS: O<sub>3</sub> daily cycles

Period: 20160801-20160901

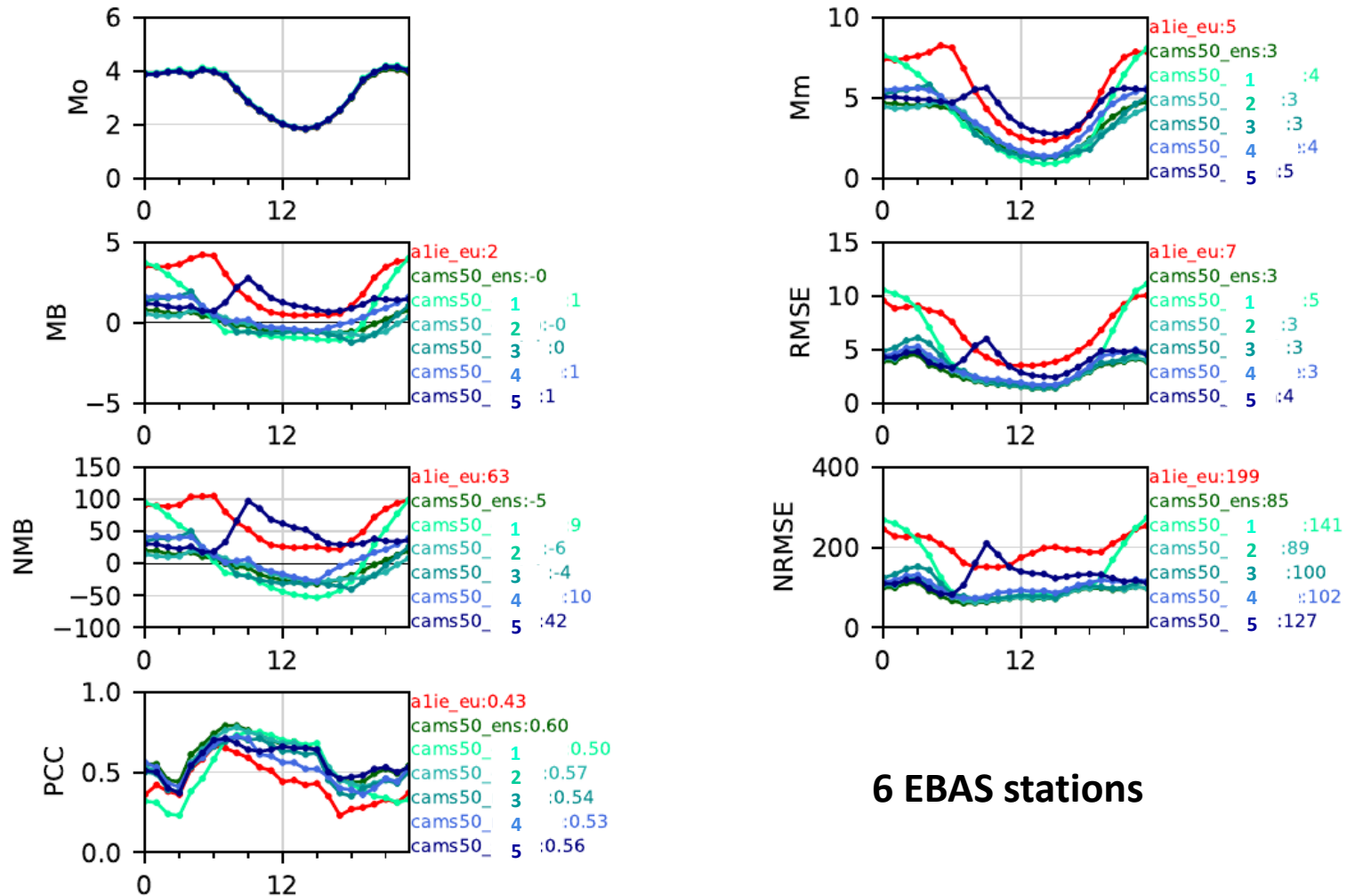


**113 EBAS stations**

Mo : conc observations (ppb), Mm : conc model (ppb), MB : mean bias (ppb), NMB : normalized mean bias (%), NRMSE : normalized RMSE (%), PCC: correlation coefficient.

# MONARCH vs CAMS: NO<sub>2</sub> daily cycles

Period: 20160801-20160901



6 EBAS stations

Mo : conc observations (ppb), Mm : conc model (ppb), MB : mean bias (ppb), NMB : normalized mean bias (%), NRMSE : normalized RMSE (%), PCC: correlation coefficient.

# Conclusions

**We have assessed the performance of the online multiscale MONARCH v2.0 Model to forecast the air quality in Europe in the context of CALIOPE and CAMS\_50.II**

- MONARCH performance for **O<sub>3</sub>**
  - Better skills than CALIOPE (WRF-CMAQ)
  - In the range of other CAMS\_50 models.
- MONARCH performance for **NO<sub>2</sub>**
  - General overestimation in rural stations.
  - Underestimation near urban stations.
- MONARCH performance for **PM**
  - General underestimation, more important in PM10 than in PM2.5
  - Ongoing work in SOA formation may reduce the bias.
- The replacement inside **CALIOPE system** foreseen during 2019.
- Next tasks within **CAMS\_50.II**:
  - Coupling with IFS forecast initial and boundary conditions.
  - Rerun 2016
  - Expand the evaluation analysis with EIONET stations with quality control flags.



# Thank you!



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Atmosphere  
Monitoring Service



GOBIERNO  
DE ESPAÑA

MINISTERIO  
DE ECONOMÍA  
Y COMPETITIVIDAD



## Acknowledgments

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